A8912-3

Special Report
Geophysical Activity in 1988

SEG

Russell J. Senti*

Report of the SEG Geophysical Activity Committee. Members of the Committee are Russell J. Senti, Chairman; Karen B. Goodfellow, Assistant Chairman; and Jesus A. Bilbao, Dana Cain, Lionel Cane, Charles E. Curtis, Harry Espey, Lin Evans, Ronald Hartman, R. J. Henderson, Dan D. Hollis, Richard Hopkins, W. W. (Bill) Krauter, Fritz P. Kronberger, Dennis P. Kucinskas, Robert C. Lucas, Wes Meyers, Gerald E. Montgomery, James Sides, Mike Spradley, Frank Stirling, Paul Stoffa, and Don Watts.

Introduction

Statistical data on worldwide geophysical activity in 1988 is presented in this report. Data were gathered from survey questionnaires that were mailed to 460 oil companies, contractors, government agencies, and institutions throughout the free world. Information has been collected from all users of geophysical techniques in the areas of petroleum, mining, groundwater and geothermal exploration, and from those who employ geophysical methods in engineering, environmental, oceanography, and research. Two hundred sixty-nine questionnaires were returned for this report. This compares to 218 questionnaires returned for the 1987 report and 251 returns for the 1986 report.

Detailed data were gathered on airborne, drill-hole, land, marine, and transition zone geophysical surveys. Statistics were compiled on miles of coverage, number of stations, drill-hole footage, time spent in crew-months or man-months, and acquisition costs. Data not supplied on the questionnaires by the respondents were estimated on the basis of statistical averaging for the area and techniques reported. This process is necessary to avoid distortion of individual statistical items.

This report, when compared to past annual reports, provides a basis for detecting and analyzing trends in technological developments and exploratory trends in geographical areas. Changes in these trends reflect the influence of factors such as oversupply of a particular natural resource, technological advances, and changes in economic conditions, governmental regulations, production controls by a country or countries, and exploration philosophy. Cost figures are also sensitive to many factors such as operational environment, length and nature of the survey, type of instrumentation, etc. Unit costs reported by universities are substantially lower than those reported by industry due to the use of student labor and donated equipment. These costs, however, must be averaged with industry costs to accommodate the format of the report. Therefore, when examining unit cost figures, one must be aware of the broad spectrum of activity embraced by individual categories.

In response to an increase in activity on surveys performed in transition zones, the areas between normal marine and land surveys, a new table (4A) is included for the first time in this 1988 report. This new table is an expansion of the transition zone part of Table 8 which shows where the transition zone surveys are being conducted in the U.S. Additionally, 3-D surveys are reported in individual geographical areas throughout all the tables in this year's report.

Table 1. Total worldwide expenditures during 1988 in US$ (thousand's) by survey type and objective.

	Petroleum[1]									
Type	Exploration	Development	Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
Land	916,757	17,737	20,935	655	6,271	3,185	2,020		10,726	978,286
Transition zone	13,574	33							67	13,675
Marine	478,125	18,185	4,655		7,175			3,670	9,703	521,511
Airborne	14,627		13,558	5			300	472	503	29,464
Drill hole	1,441	1,288	227	49	453	25	192		187	3,861
Total	1,424,524	37,243	39,375	708	13,899	3,210	2,511	4,141	21,186	1,546,798

[1]Includes processing and interpretation costs for land, transition zone, and marine. See text for details.

Note: All tables in this report where figures are expressed in thousands of dollars have been rounded off as individual items; but the computer keeps track of all the truncated numbers and then the sums of the individual items are rounded off. As a result of this procedure, the rounded individual items may not add up precisely to the rounded sums.

*Texaco Inc., P.O. Box 1404, Houston, TX 77251.

1988 Highlights

Worldwide expenditures on geophysical exploration in 1988 were up 6 percent from 1987 (see Table 1). The increase came primarily in the petroleum area where total petroleum expenditures rose 4 percent. Petroleum exploration expenditures increased 3.5 percent while expenditures for petroleum development showed an even larger increase of 23 percent over 1987 levels. Use of geophysics for petroleum development or "production geophysics" declined slightly for land activity, down 12 percent. However, the use of geophysics for petroleum development for marine activity nearly doubled, up 88 percent over last year. Petroleum development marine activity captured 3.7 percent of the total petroleum expenditures for marine activity in 1988. Petroleum development land activity was 1.9 percent of the total petroleum expenditures for land activity.

Overall, total petroleum expenditures, which accounted for 94.5 percent of the total expenditures in 1988, increased in all areas except marine: land (+12.7%), marine (−9.9%), and transition zone (+34.5%). All the other survey objectives showed increases in expenditures as well: environmental (+13.1%), oceanography (+135.5%), engineering (+27.4%), mining (+46.4%), research (+103.8%), groundwater (+40.4%), and geothermal (+185.3%). The large increases in research, oceanography, and geothermal may be a result of under-reporting for these survey objectives in 1987.

Distribution of expenditures by geographic area and survey objective is shown in Table 2. Only 29.3 percent of all expenditures for geophysical work was spent in the United States, compared to 31.8 percent in 1987, 32.6 percent in 1986, and 44 percent in 1985. There was $875 million less spent on geophysical exploration in the U.S. in 1988 than in 1985. However, the following areas showed an increase in total geophysical expenditures compared to 1987: Canada (+22%), Europe (+27.6%), Africa (+13.2%), Middle East (+29.2%), and the Far East (+11.9%). The U.S. showed a decrease of 22.7% in 1988 over 1987. South America had a 19.2 percent decrease in expenditures, while Australia/New Zealand had a 32 percent decline and Mexico decreased 18.3 percent in activity over last year.

The costs of processing and interpretation are included in Figures 1 and 2 and the petroleum columns of Tables 1 and 2. The remaining columns in Tables 1 and 2 and all of Tables 3-17 show acquisition costs only. Average costs of processing and interpretation were obtained from various processing contractors and oil companies to arrive at a figure of U.S.$450 per line-mile last year. It is understood that these costs were lowered significantly in 1987; however, in order to compare acquisition costs between 1987 and 1988, processing and interpretation costs were kept a constant.

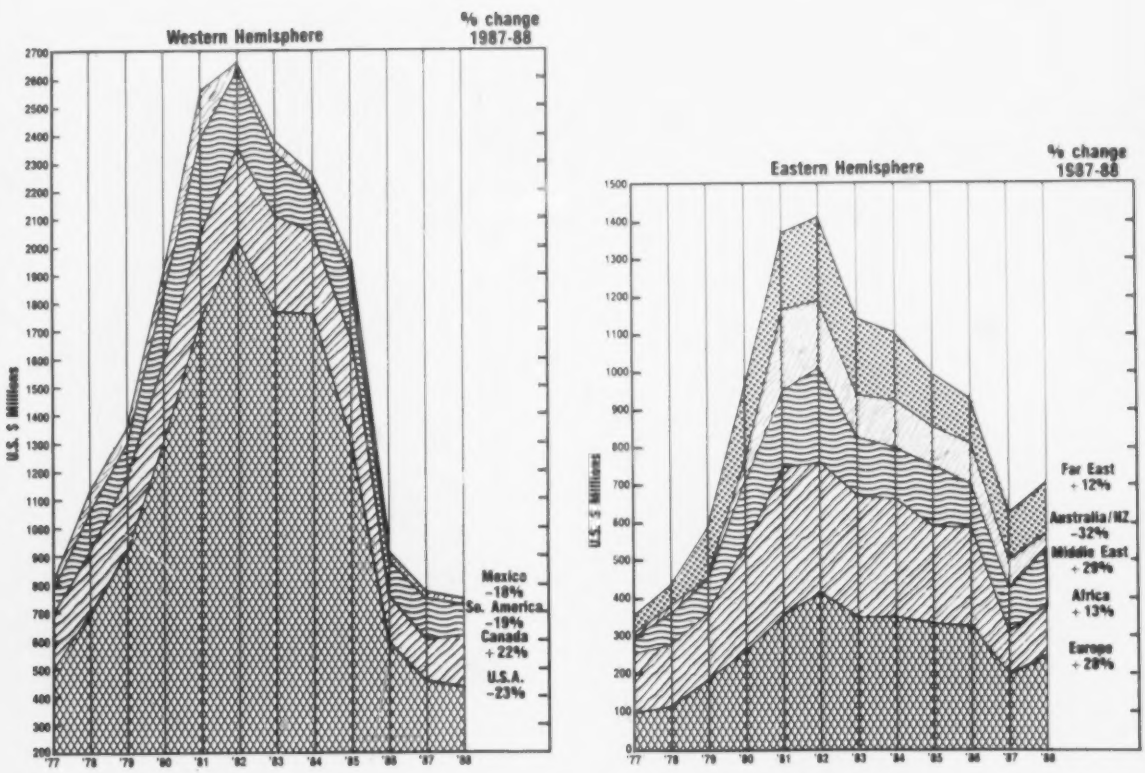

FIG. 1. Total expenditures on petroleum exploration and development, 1977-88.

Table 2. Total worldwide expenditures during 1988 in US$ (thousands) by area and survey objective.

Area	Petroleum[1] Exploration	Petroleum[1] Development	Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	5,719				500			3,583	6,925	16,727
U.S.A.	416,134	22,522	6,635	626	1,998	323	615		5,037	453,891
Canada	178,116	122	9,193	8	164		1		3,494	191,098
Mexico	14,808		15							14,823
South America	116,199		965		1,945	174			1,815	121,098
Europe	245,674	8,584	6,809		7,322	637	100		736	269,862
Africa	121,247	4,174	6,192		890	150	423		287	133,363
Middle East	151,052	1,340	359		109	806				153,665
Far East	132,066	501	4,165		945	1,030	462	559	181	139,907
Australia/ New Zealand	43,509		5,043	74	26	90	910		2,712	52,364
Total	1,424,524	37,243	39,375	708	13,899	3,210	2,511	4,141	21,186	1,546,798

[1]Includes processing and interpretation costs for land, transition zone, and marine. See text for details.

Petroleum exploration

Over 94 percent of all geophysical dollars were spent on petroleum exploration and development (U.S.$1.462 billion) in 1988. Expenditures for petroleum exploration and development declined in the following areas: United States (−3.3%), Mexico (−18.4%), South America (−21.9%), and Australia/New Zealand (−40%). The Far East increased 9.8 percent, Africa 12.5 percent, Canada 22.2 percent, Europe 27.9 percent, and the Middle East had the largest increase (+28.3%) in 1988. Petroleum exploration and development expenditures declined 2.4 percent in the Western Hemisphere. Eastern Hemisphere activity rose 13.8 percent over 1987's level. A 10-year history of petroleum exploration and development activity in both hemispheres is shown in Figure 1.

(Text continued on p. 42)

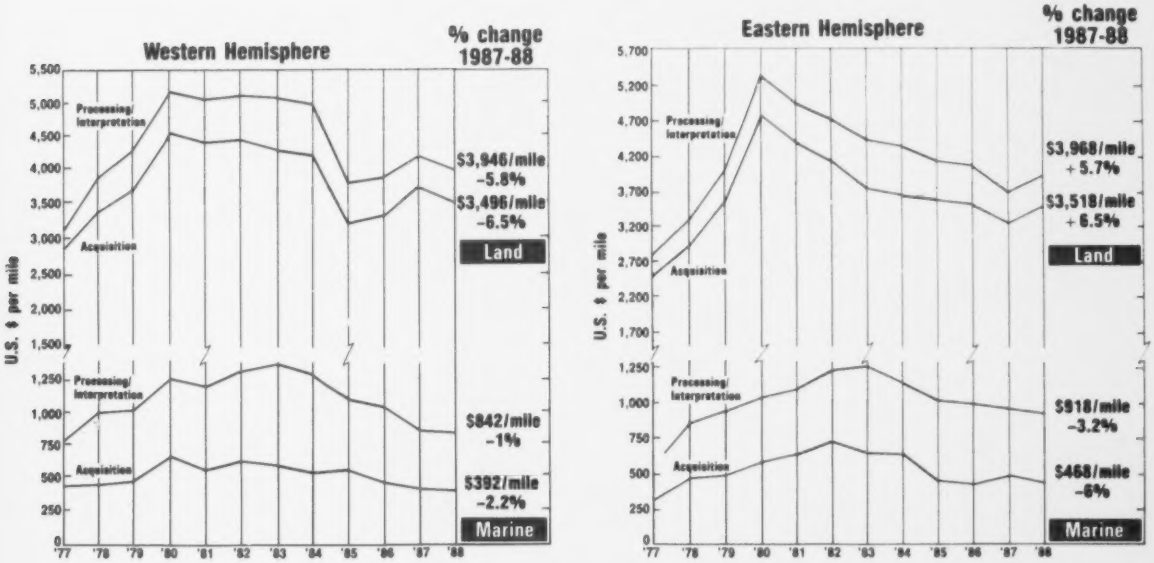

FIG. 2. Average cost per mile for petroleum seismic surveys, 1977-88.

Table 3. Worldwide petroleum land seismic activity in 1988[1].

Area	Acquisition costs – US$	Line-miles	Crew-months		Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
			Company*	Contract				
U.S.A.	238,779,068	62,089	149.5	1,362.2	1,511.7	41	157,945	3,845
	[5,167,100]	[145]	[6.3]	[9.0]	[15.3]	[9]	[337,718]	[35,439]
Canada	138,174,836	37,932	70.9	368.6	439.5	86	314,348	3,642
	[12,596,975]	[317]		[29.0]	[29.0]	[10]	[434,378]	[39,663]
Mexico	10,341,898	6,872		224.5	224.5	30	46,066	1,504
South America	60,261,197	21,130	2.0	416.6	418.6	50	143,958	2,851
Europe	74,043,750	17,649		343.7	343.7	51	215,431	4,195
	[20,400,000]	[703]		[34.0]	[34.0]	[20]	[600,000]	[29,018]
Africa	75,453,296	21,151		341.8	341.8	61	220,752	3,567
Middle East	127,175,185	31,974		340.5	340.5	93	373,495	3,977
Far East	32,778,557	12,352		239.0	239.0	51	137,148	2,653
Australia/ New Zealand	25,413,052	12,054		118.5	118.5	101	214,456	2,108
Total	782,420,839	223,203	222.5	3,755.4	3,977.9	56	196,689	3,505
	[38,164,075]	[1,166]	[6.3]	[72.0]	[78.3]	[14]	[487,408]	[32,719]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 4. Worldwide petroleum land seismic line-miles in 1988 by energy source and 3-D survey.

Area	Dynamite	Compressed air	Gas exploder	Weight drop	Vibrator	3-D surveys		Total line-miles
						Line-miles	[Square-miles]	
U.S.A.	24,413	640	350	64	36,081	540	[145]	62,089
Canada	25,447	1,308		656	9,047	1,474	[317]	37,932
Mexico	2,067				4,805			6,872
South America	10,102	4,492		686	5,580	270		21,130
Europe	4,393	1,600		124	11,532		[703]	17,649
Africa	4,226	4,600			11,975	350		21,151
Middle East	15,099	3,500		1,600	11,565	210		31,974
Far East	8,483	1,000		1,630	1,239			12,352
Australia/ New Zealand	1,070	1,600			9,384			12,054
Total	95,300	18,740	350	4,760	101,208	2,844	[1,166]	223,203 [1,166]

Table 4A. Worldwide petroleum transition zone seismic activity in 1988[1].

Area	Acquisition costs — US$	Line-miles	Crew-months		Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
			Company*	Contract				
U.S.A.	2,914,700	17,410		48.0	48.0	362	60,722	167
South America	333,000	1,500		19.0	19.0	78	17,526	222
Africa	2,670,000	4,069		11.5	11.5	353	232,173	656
Middle East	500,000	500		9.5	9.5	53	52,631	1,000
Far East	1,400,000	3,211		35.0	35.0	91	40,000	435
Total	7,817,700	26,690		123.0	123.0	217	63,559	293

*Total includes government and university activity, if any.

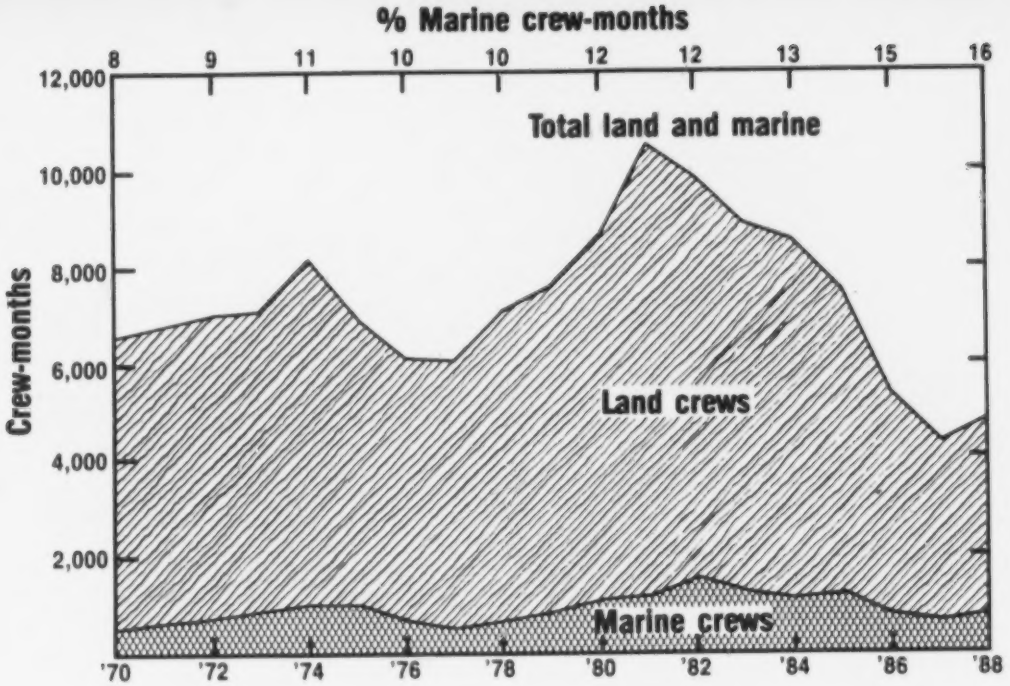

FIG. 3. Worldwide seismic activity in crew-months, 1970-88.

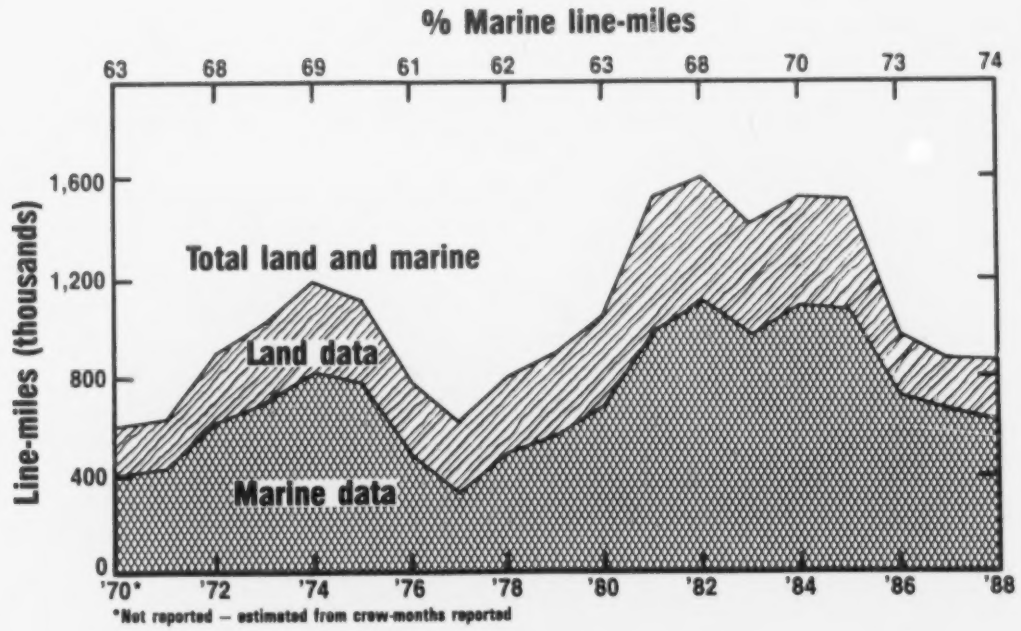

FIG. 4. Worldwide seismic activity in line-miles, 1970-88.

Table 5. Worldwide petroleum marine seismic activity in 1988.

Area	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
			Company*	Contract				
International	5,719,000	5,700		8.0	8.0	712	714,875	1,003
U.S.A.	91,473,171	248,640	51.0	197.8	248.8	999	367,657	367
Canada	1,442,400	5,440		8.3	8.3	655	173,783	265
South America	24,138,300	44,450		52.0	52.0	854	464,198	543
Europe	88,270,120	158,070		220.0	220.0	718	401,154	558
Africa	21,462,000	26,878		62.1	62.1	432	345,615	798
Middle East	5,073,000	4,945		14.8	14.8	334	342,770	1,025
Far East	38,141,600	123,336		151.2	151.2	815	252,225	309
Australia/ New Zealand	3,208,200	20,707		25.0	25.0	828	128,328	154
Total	278,928,491	638,168	51.0	739.2	790.2	807	352,957	437

*Total includes government and university activity, if any.

Table 6. Worldwide petroleum marine seismic line-miles in 1988 by energy source and 3-D survey.

Area	Dynamite	Compressed air	3-D surveys Line-miles	Total line-miles
International		5,700		5,700
U.S.A.		134,366	114,274	248,640
Canada		4,040	1,400	5,440
South America		44,450		44,450
Europe		136,224	21,846	158,070
Africa		25,504	1,374	26,878
Middle East	48	4,897		4,945
Far East		118,445	4,891	123,336
Australia/ New Zealand		20,707		20,707
Total	48	494,334	143,785	638,168

Table 7. Worldwide average unit costs in 1988 for petroleum surveys.

Area, survey type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew-month or man-month*	Average cost/ mile or (foot) or [station]
International						
Marine						
Seismic (*P*-wave)						
Compressed air	8.0	5,700	5,719,000	713	714,875	1,003
U.S.A.						
Land						
Seismic (*P*-wave)						
Dynamite	744.6	24,413	132,920,422	33	178,501	5,445
Dynamite	6.0*	[588]	25,750	[98]*	4,292*	[44]
Compressed air	20.8	586	2,700,200	28	129,506	4,608
Gas exploder	7.0	350	6,700	50	957	19
Weight drop	3.6	64	208,830	18	58,008	3,263
Vibratory	671.4	35,755	88,762,255	53	132,199	2,482
Seismic (*S*-wave)						
Compressed air	2.0	54	305,000	27	152,500	5,648
Vibratory	5.0	200	967,000	40	193,400	4,835
Seismic (refraction)						
Vibratory	4.0	126	489,280	32	122,320	3,883
3-D Seismic						
Line-miles	50.0	540	10,896,972	11	217,939	20,180
Square miles	15.3	145	5,167,100	10	337,719	35,440
Gravity	35.9	2,865	441,750	80	12,288	154
Gravity	7.0	[6,208]	346,750	[887]	49,536	[56]

Table 7. Worldwide average unit costs in 1988 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
U.S.A., Land, continued						
Magnetotelluric						
Natural field	2.0	100	530,000	50	265,000	5,300
Natural field	10.0	[131]	275,000	[13]	27,500	[2,099]
Controlled source	6.5	155	225,000	24	34,615	1,452
Controlled source	1.3	[72]	42,000	[55]	32,308	[583]
VSPs	30.0	[125]	1,100,000	[4]	36,667	[8,800]
Transition zone						
Seismic (*P*-wave)						
Dynamite	4.5	70	1,800,000	16	400,000	25,714
Compressed air	43.5	17,340	1,114,700	399	25,625	64
Marine						
Seismic (*P*-wave)						
Compressed air	182.5	134,366	61,252,171	736	335,628	456
3-D seismic						
Line-miles	66.3	114,274	30,221,000	1,724	455,822	264
Gravity	13.5	22,645	673,000	1,671	49,668	30
Magnetic	7.0	7,800	30,000	1,114	4,286	4
VSPs	.1	1	50,000	10	500,000	50,000
VSPs	8.0	[15]	300,000	[2]	37,500	[20,000]
Airborne						
Magnetic	12.5	75,200	874,500	6,016	69,960	12
Combined Em/Mag.						
Time domain	1.0	3,200	51,200	3,200	51,200	16
Frequency domain	2.0	5,000	600,000	2,500	300,000	120
Remote sensing						
Side-looking radar	2.7	180,000	1,300,000	66,667	481,481	7
Drill hole						
Sonic/velocity logging	6.0	[112]	1,680,000	[19]	280,000	[15,000]
Sonic/velocity logging	12.0	[306]	2,509,000	[26]	209,083	[8,199]
Other	.4*	(2,500)	35,000	(6,250)	87,500*	(14)
Other	19.0	[3,990]	1,097,250	[210]	57,750	[275]
Canada						
Land						
Seismic (*P*-wave)						
Dynamite	236.6	25,397	86,485,285	107	365,441	3,405
Dynamite	6.5	[49]	1,400,000	[8]	215,385	[28,571]
Compressed air	26.4	1,308	6,261,000	49	236,711	4,787
Compressed air	1.0	[31]	230,400	[31]	230,400	[7,432]
Weight drop	8.0	656	1,830,000	82	228,750	2,790
Vibratory	140.4	9,047	31,432,151	64	223,796	3,474
Vibratory	7.5	[37]	1,700,000	[5]	226,667	[45,946]
Seismic (*S*-wave)						
Dynamite	1.0	50	200,000	50	200,000	4,000
3-D seismic						
Line-miles	12.0	1,474	8,636,000	123	719,667	5,859
Square miles	28.0	317	12,340,975	11	440,749	38,857
Square miles	1.0	[6]	256,000	[6]	256,000	[42,667]
Gravity	5.0	4,560	618,000	912	123,600	136
Gravity	12.0*	2,500	122,900	208*	10,242*	49
Other	3.0	1,875	56,250	625	18,750	30
Other	3.5	[133]	510,000	[38]	145,714	[3,835]
Marine						
Seismic (*P*-wave)						
Compressed air	7.1	4,040	442,400	569	62,310	110
3-D seismic						
Line-miles	1.2	1,400	1,000,000	1,167	833,333	714
Gravity	1.0	1,500	50,000	1,500	50,000	33
Airborne						
Combined EM/Mag.						
Frequency domain	20.0	50,000	4,000,000	2,500	200,000	80
Drill hole						
Resistivity	.1	(1,500)	5,000	(15,000)	50,000	(3)
Other	.2	(200)	22,000	(1,000)	110,000	(110)
Other	.8*	[160]	44,000	[200]*	55,000*	[275]

Table 7. Worldwide average unit costs in 1988 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Mexico						
Land						
Seismic (*P*-wave)						
Dynamite	124.0	2,067	4,814,698	17	38,828	2,329
Vibratory	100.5	4,805	5,527,200	48	54,997	1,150
Gravity	60.0	5,833	1,000,000	97	16,667	171
Magnetotelluric						
Natural field	7.0	[56]	74,000	[8]	10,571	[1,321]
VSPs	12.0	[29]	300,000	[2]	[25,000]	[10,345]
South America						
Land						
Seismic (*P*-wave)						
Dynamite	213.4	9,906	19,469,135	46	91,233	1,965
Compressed air	65.8	4,492	21,718,000	68	330,061	4,835
Weight drop	7.0	490	2,450,000	70	350,000	5,000
Vibratory	104.6	5,580	6,459,246	53	61,752	1,158
Seismic (refraction)						
Dynamite	.4	196	4,000	490	10,000	20
Weight drop	.4	196	4,000	490	10,000	20
3-D seismic						
Line-miles	27.0	270	10,156,816	10	376,178	37,618
Magnetic	5.0	31	1,050,000	6	210,000	33,546
Magnetotelluric						
Natural field	2.0	[10]	200,000	[5]	100,000	[20,000]
Transition zone						
Seismic (*P*-wave)						
Compressed air	19.0	1,500	333,000	79	17,526	222
Marine						
Seismic (*P*-wave)						
Compressed air	52.0	44,450	24,138,300	855	464,198	543
Gravity	3.2	4,500	103,000	1,385	31,692	23
Magnetic	2.2	2,500	12,000	1,111	5,333	5
Airborne						
Gravity	12.0	22,550	1,039,800	1,879	86,650	46
Europe						
Land						
Seismic (*P*-wave)						
Dynamite	140.4	4,393	21,035,000	31	149,822	4,788
Compressed air	25.0	1,600	6,140,000	64	245,600	3,838
Weight drop	8.0	124	790,000	16	98,750	6,371
Vibratory	170.3	11,532	46,078,750	68	270,574	3,996
3-D seismic						
Square miles	34.0	703	20,400,000	21	600,000	29,018
Gravity	2.5	1,065	160,000	426	64,000	150
Gravity	44.0	[8,800]	176,000	[200]	4,000	[20]
Resistivity	15.5	[234]	135,625	[15]	8,750	[580]
Electromagnetic						
Time domain	1.0	31	100,000	31	100,000	3,226
VSPs	29.3	[88]	850,000	[3]	29,010	[9,659]
Marine						
Seismic (*P*-wave)						
Compressed air	188.3	136,224	73,285,520	723	389,154	538
3-D seismic						
Line-miles	31.7	21,846	14,984,600	689	472,402	686
Gravity	3.5	3,500	160,000	1,000	45,714	46
Airborne						
Combined Em/Mag.						
Frequency domain	.4	1,000	300,000	2,500	750,000	300
Drill hole						
Sonic/velocity logging	1.9	[4]	40,000	[2]	21,053	[10,000]
Other	1.0	[3,000]	63,000	[2,857]	60,000	[21]
Other	2.2	(18,200)	317,000	(8,089)	140,889	(17)

Table 7. Worldwide average unit costs in 1988 for petroleum surveys (cont).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Africa						
Land						
Seismic (*P*-wave)						
Dynamite	96.3	4,226	15,957,273	44	165,704	3,776
Compressed air	51.0	4,600	23,048,000	90	451,922	5,010
Vibratory	159.5	11,975	24,889,673	75	156,048	2,078
3-D seismic						
Line-miles	35.0	350	11,558,350	10	330,239	33,024
Gravity	36.0	14,690	2,544,000	408	70,667	173
Gravity	14.7	[6,018]	407,240	[409]	27,703	[68]
Gravity	.7*	[250]	45,000	[357]*	64,286*	[180]
Magnetotelluric						
Natural field	2.0	150	30,000	75	15,000	200
Natural field	10.0	[300]	1,200,000	[30]	120,000	[4,000]
VSPs	2.3	[7]	70,000	[3]	30,435	[10,000]
Transition zone						
Seismic (*P*-wave)						
Dynamite	1.5	134	670,000	89	446,667	5,000
Compressed air	3.0	3,065	1,200,000	1,022	400,000	391
3-D seismic						
Line-miles	7.0	870	800,000	124	114,286	920
Marine						
Seismic (*P*-wave)						
Compressed air	54.8	25,504	19,942,700	465	363,918	782
3-D seismic						
Line-miles	7.3	1,374	1,520,000	188	208,219	1,106
Gravity	5.0	6,050	132,000	1,210	26,400	22
Magnetic	1.0	1,000	5,000	1,000	5,000	5
Airborne						
Magnetic	2.0	15,200	565,000	7,600	282,500	37
Middle East						
Land						
Seismic (*P*-wave)						
Dynamite	146.5	15,099	50,025,981	103	341,474	3,313
Compressed air	42.0	3,500	17,352,000	83	413,143	4,958
Weight drop	12.0	1,600	4,791,403	133	399,370	2,995
Vibratory	119.0	11,565	43,717,028	97	367,370	3,780
3-D seismic						
Line-miles	21.0	210	11,288,773	10	537,561	53,756
Gravity	13.0	5,328	800,000	410	61,538	150
Electromagnetic						
Time domain	4.5	[700]	250,000	[156]	55,556	[357]
Magnetotelluric						
Natural field	2.0	[60]	200,000	[30]	100,000	[3,333]
VSP's	1.6	[5]	50,000	[3]	31,250	[10,000]
Transition zone						
Seismic (*P*-wave)						
Dynamite	9.5	500	500,000	53	52,632	1,000
Marine						
Seismic (*P*-wave)						
Dynamite	.5	48	96,000	96	192,000	2,000
Compressed air	14.3	4,897	4,977,000	342	348,042	1,016
Airborne						
Magnetic	8.1	19,532	1,784,280	2,411	220,281	91
Drill hole						
Other	.5	(1,000)	40,000	(2,000)	80,000	(40)

Table 7. Worldwide average unit costs in 1988 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Far East						
Land						
Seismic (*P*-wave)						
Dynamite	185.0	8,483	17,013,657	46	91,966	2,006
Compressed air	12.0	1,000	3,169,000	83	264,083	3,169
Weight drop	23.3	1,630	8,150,000	70	349,785	5,000
Vibratory	18.7	1,239	4,445,900	66	237,749	3,588
Gravity	.5	[200]	104,000	[400]	208,000	[520]
Electromagnetic						
Time domain	1.0	31	180,000	31	180,000	5,806
Time domain	1.0	46	180,000	47	180,000	3,863
Transition zone						
Seismic (*P*-wave)						
Compressed air	35.0	3,211	1,400,000	92	40,000	436
Marine						
Seismic (*P*-wave)						
Compressed air	149.3	118,445	35,459,600	793	237,490	299
3-D seismic						
Line-miles	1.9	4,891	2,682,000	2,561	1,404,188	548
Gravity	5.0	7,750	131,000	1,550	26,200	17
Airborne						
Gravity	3.0	3,700	455,100	1,233	151,700	123
Magnetic	2.1	9,536	235,827	4,435	109,687	25
Drill hole						
Other	.2	(1,500)	100,000	(6,000)	400,000	(67)
Australia/New Zealand						
Land						
Seismic (*P*-wave)						
Dynamite	13.5	1,070	2,525,121	79	187,046	2,360
Compressed air	25.0	1,600	6,140,000	64	245,600	3,838
Vibratory	80.0	9,384	16,747,931	117	209,349	1,785
Gravity	2.6	[553]	54,281	[211]	20,718	[98]
VSPs	1.0*	[3]	5,700	[3]*	5,700*	[1,900]
Marine						
Seismic (*P*-wave)						
Compressed air	25.0	20,707	3,208,200	828	128,328	155
Gravity	3.0	3,500	85,000	1,167	28,333	24

Petroleum seismic surveys

The seismic method accounted for 98 percent of all expenditures in petroleum geophysical activity. This statistic plus the strong tendency for wildcatting to parallel seismic activity, has caused those interested in forecasts of petroleum exploration to regard seismic activity as a barometer for exploration. A 10-year history of the cost of petroleum seismic surveys in both the Eastern and Western Hemispheres is shown in Figure 2. In the Western Hemisphere, average acquisition costs per mile of land seismic surveys declined 6.5 percent, while marine costs decreased 2.2 percent. In the Eastern Hemisphere, acquisition cost per mile for land seismic increased 6.5 percent, while marine costs decreased 6 percent. The total number of miles of seismic data recorded worldwide was up 10.2 percent for land and down 4.1 percent for marine work as compared to 1987 levels. Distribution of expenditures, line-miles, and crew months on seismic activity is shown on Tables 3 and 5 which do not include activity reported for transition zone areas. The transition zone data are found in Table 4A.

Vibroseis was again the most popular land seismic energy source used this year with dynamite the second most used source. These two energy sources accounted for 92 percent of all seismic land work in 1988 (see Table 4). In marine work, the compressed air energy source was the most popular source, with air guns shooting 99.6 percent of the total line-miles recorded (see Table 6).

One can refer to Table 7 for a more comprehensive breakdown of statistical data on petroleum surveys, which are sorted by geographic area. Table 8 shows petroleum seismic activity by states in the U.S. Texas and Michigan accounted for 40.8 percent of all U.S. onshore expenditures on seismic exploration. The states with the largest increases in 1988 were Alaska, Arkansas, Florida, Kansas, Nevada, New Mexico, Oklahoma, and Wyoming. No activity was reported from the following states that had activity in 1987: Arizona, Georgia, Ohio, South Carolina, and South Dakota.

(Text continued on p. 45)

Table 8. U.S.A. petroleum seismic activity in 1988 by area[1].

Survey type, state	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Land					
Alaska	7,016,500	1,480	.0	22.0	22.0
Alabama	4,187,012	901	2.0	20.7	22.7
Arkansas	1,041,685	296	.0	7.0	7.0
California	18,269,529	3,869	15.1	70.0	85.1
	(1,518,170)	(110)	(.0)	(11.0)	(11.0)
	[652,000]	[25]	[.0]	[2.0]	[2.0]
Colorado	6,189,190	2,435	.6	57.2	57.8
Florida	7,146,239	817	10.5	11.5	22.0
Idaho	370,000	72	2.0	.0	2.0
Illinois	496,380	188	.0	5.0	5.0
Indiana	371,000	110	.0	2.0	2.0
Kansas	4,761,284	2,304	.0	42.5	42.5
Kentucky	50,000	35	.0	.5	.5
Louisiana	12,929,137	2,614	.0	79.3	79.3
	(611,081)	(20)	(.0)	(2.0)	(2.0)
	[750,000]	[15]	[.0]	[3.0]	[3.0]
Maryland	500,000	330	.0	5.0	5.0
Michigan	43,694,150	7,326	44.0	192.8	236.8
Missouri	48,818	17	.0	.1	.1
Mississippi	6,899,500	1,393	5.0	36.0	41.0
Montana	2,822,561	592	3.2	15.3	18.5
	[903,000]	[50]	[1.7]	[.0]	[1.7]
North Carolina	400,000	270	.0	4.0	4.0
North Dakota	5,215,455	1,617	14.0	20.7	34.7
Nebraska	611,166	278	.0	4.5	4.5
New Mexico	7,030,986	3,709	2.5	65.0	67.5
	(81,245)	(10)	(.0)	(1.0)	(1.0)
Nevada	4,470,775	779	3.0	19.4	22.4
New York	37,000	14	.3	.0	.3
Oklahoma	20,246,330	6,289	4.8	146.7	151.5
	(292,173)	(20)	(.0)	(2.0)	(2.0)
	[350,000]	[10]	[.0]	[2.0]	[2.0]
Oregon	1,601,100	350	.0	8.0	8.0
	(1,214,621)	(60)	(.0)	(6.0)	(6.0)
Pennsylvania	387,000	190	.0	3.0	3.0
Tennessee	50,000	35	.0	.5	.5
Texas	49,332,523	18,608	22.1	365.6	387.7
	(4,213,701)	(229)	(.0)	(21.6)	(21.6)
	[1,801,100]	[31]	[4.2]	[.0]	[4.2]
Utah	3,652,596	384	3.0	9.2	12.2
Virginia	300,000	200	.0	3.0	3.0
Washington	2,411,350	393	7.9	5.5	13.4
	(904,981)	(40)	(.0)	(4.0)	(4.0)
West Virginia	200,000	130	.0	2.0	2.0
Wyoming	15,142,830	3,521	9.5	88.0	97.5
	(2,061,000)	(51)	(.0)	(2.4)	(2.4)
	[711,000]	[14]	[.4]	[2.0]	[2.4]
Total land	227,882,096	61,549	149.5	1,312.2	1,461.7
	(10,896,972)	(540)	(.0)	(50.0)	(50.0)
	[5,167,100]	[145]	[6.3]	[9.0]	[15.3]
Transition zone					
Alaska	1,800,000	70	.0	4.5	4.5
Alabama	179,900	4,450	.0	11.0	11.0
Louisiana	308,700	11,440	.0	26.0	26.0
Maryland	175,000	100	.0	1.5	1.5
Texas	451,100	1,350	.0	5.0	5.0
Total transition zone	2,914,700	17,410	.0	48.0	48.0

[1]All data enclosed in (braces) pertain to 3-D surveys reported in line-miles; data in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 8. U.S.A. petroleum seismic activity in 1988 by area[1] (cont.).

Survey type, state	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Marine					
Off Alaska	6,251,100	7,421	.0	11.1	11.1
	(1,000,000)	(1,007)	(.0)	(2.4)	(2.4)
West Coast	495,700	6,524	.0	8.9	8.9
	(1,586,000)	(1,700)	(3.0)	(.0)	(3.0)
Gulf Coast	51,441,600	119,421	24.5	127.0	151.5
	(27,635,000)	(111,567)	(23.5)	(37.4)	(60.9)
Unknown	3,063,771	1,000	.0	11.0	11.0
Total marine	61,252,171	134,366	24.5	158.0	182.5
	(30,221,000)	(114,274)	(26.5)	(39.8)	(66.3)
Total U.S.A.	292,048,967	213,325	174.0	1,518.2	1,692.2
	(41,117,972)	(114,814)	(26.5)	(89.8)	(116.3)
	[5,167,100]	[145]	[6.3]	[9.0]	[15.3]

Table 9. Canada petroleum seismic activity in 1988 by area[1].

Survey type, province	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Land					
Undesignated	6,149,260	2,635	.0	52.0	52.0
Alberta	98,346,594	28,350	47.5	262.4	309.9
	(1,996,000)	(455)	(.0)	(8.4)	(8.4)
	[11,916,975]	[315]	[.0]	[28.5]	[28.5]
British Columbia	8,006,249	2,367	2.5	28.4	30.9
Manitoba	2,528,900	426	4.0	.0	4.0
Northwest territories	7,611,000	233	.7	3.2	3.9
	(6,640,000)	(1,019)	(.0)	(3.6)	(3.6)
	[680,000]	[2]	[.0]	[.5]	[.5]
Ontario	20,000	8	.2	.0	.2
Saskatchewan	6,876,833	2,437	16.0	10.4	26.4
Total land	129,538,836	36,458	70.9	356.6	427.5
	(8,636,000)	(1,474)	(.0)	(12.0)	(12.0)
	[12,596,975]	[317]	[.0]	[29.0]	[29.0]
Marine					
Undesignated	7,400	3,700	.0	6.0	6.0
Newfoundland	35,000	40	.0	.1	.1
	(1,000,000)	(1,400)	(.0)	(1.2)	(1.2)
Northwest territories	400,000	300	.0	1.0	1.0
Total marine	442,400	4,040	.0	7.1	7.1
	(1,000,000)	(1,400)	(.0)	(1.2)	(1.2)
Total Canada	129,981,236	40,498	70.9	363.7	434.6
	(9,636,000)	(2,874)	(.0)	(13.2)	(13.2)
	[12,596,975]	[317]	[.0]	[29.0]	[29.0]

[1]All data enclosed in (braces) pertain to 3-D surveys reported in line-miles; data in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 10. Petroleum seismic activity in Mexico in 1988.

Survey type	Acquisition costs - US$	Line-miles	Crew-months		Total months
			Company	Contract	
Land					
Various	10,341,898	6,872	.0	224.5	224.5
Total Mexico	10,341,898	6,872	.0	224.5	224.5

Most of the marine seismic activity in U.S. waters was recorded along the Gulf Coast. The transition zone data reported were from the Gulf Coast, East Coast, and off Alaska. Table 9 shows petroleum seismic activity was up in 1988 compared to 1987 for Canada. Table 10 shows Mexico had a slight decline in activity in 1988 over 1987.

A 55-year history of seismic exploration in the U.S. is shown in Figure 5.

Gravity and magnetic surveys

Table 11 shows worldwide expenditures for gravity and magnetic surveys. The 1988 data show a 44.7 percent increase in expenditures in these methods as compared to 1987. Expenditures on gravity and magnetic surveys for petroleum exploration was down 12.2 percent. Expenditures on gravity and magnetic surveys for mineral exploration was up over 100 percent from 1987's levels. Canada was the largest user of these methods for mineral exploration in 1988.

Airborne surveys

Statistical data on airborne surveys are shown in Table 12, 13A, and 13B. Expenditures for worldwide airborne surveys increased by 4 percent from 1987. The major increase was in petroleum exploration which was up 9 percent in 1988 compared to 1987.

(Text continued on p. 56)

Table 11. Total worldwide expenditures in 1988 on gravity and magnetic surveys in US$ (thousands).

Area	Petroleum		Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
	Exploration	Development								
International									6,103	6,103
U.S.A.	2,366		975	12	26	30	1		89	3,500
Canada	790		4,945							5,736
Mexico	1,000									1,000
South America	2,204		965			64			1,800	5,033
Europe	336	160	762		45					1,711
Africa	1,554	2,144	888				15		77	4,678
Middle East	1,784	800			64					2,648
Far East	925		1,013				280	551		2,770
Australia/ New Zealand	139		3,840	18	11	20	40		531	4,601
Total	11,101	3,104	13,389	30	555	114	336	551	8,601	37,784

Table 12. Total worldwide expenditures in 1988 on airborne surveys in US$ (thousands).

Area	Petroleum Exploration	Minerals	Environmental	Groundwater	Oceanography	Research	Total
U.S.A.	2,825	638					3,464
Canada	6,371	4,042					10,413
South America	2,089	965					3,054
Europe	300	3,093					3,393
Africa	565	498					1,063
Middle East	1,784						1,784
Far East	690	363		300	471		1,825
Australia/ New Zealand		3,956	4			503	4,464
Total	14,627	13,557	4	300	471	503	29,464

Table 13A. Western hemisphere airborne activity in 1988 in US$ (thousands)[1].

	USA		Canada		South America	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Gravity					22,550	1,039
Gravity	[1]	9				
Magnetic	142,400	1,459	24,675	1,111	55	2,015
Combined EM/Mag.						
Time domain	3,850	95	29,025	804		
Frequency domain	5,000	600	50,000	4,000		
VLF			45,134	1,945		
Radiometric						
Gamma ray			18,050	180		
Remote sensing						
Side-scan radar	180,000	1,300			—	
Total	331,250	3,455	166,884	8,042	22,605	3,054
	[1]	9				

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.

Table 13B. Eastern hemisphere airborne activity in 1988 in US$ (thousands).

Survey method	Europe		Africa		Middle East		Far East		Australia/New Zealand	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Gravity							3,700	455		
Magnetic			16,700	642	19,532	1,784	65,899	1,270	296,044	4,039
Electromagnetic										
Time domain			2,268	86						
Frequency domain							3,833	50		
Combined EM/Mag.										
Time domain			5,410	335						
Frequency domain	3,600	550								
Radiometric										
Gamma ray							3,833	50	167	4
Remote sensing										
Thermal infrared									24,860	200
Microwave radiometry									870	20
Multispectral scanning									24,860	200
Remote sensing										
Multispectral scanning	41	2,843								
Total	3,641	3,393	24,378	1,063	19,532	1,784	77,265	1,825	346,801	4,464

Table 14A. Western hemisphere land mining activity in 1988 in US$ (thousands).

	USA		Canada		Mexico	
	Line-miles [stations]	Cost	Line-miles [stations]	Cost	Line-miles [stations]	Cost
Seismic (*P*-wave)						
Dynamite	36	79				
Seismic (refraction)						
Dynamite	49	91				
Gravity	30	5	3,343	172		
Gravity	[1,291]	77	[3]	21		
Magnetic	7,075	289	91,027	3,619		
Magnetic	[2]	10	[7]	18		
Resistivity	5	5				
Resistivity	[5]	78				
Self-potential	5	5				
Electromagnetic						
Time domain	50	50	2,455	246		
Time domain	[22]	80			[52]	1
Frequency domain	10	15	257	34		
Frequency domain	[20]	10	[3]	4		
VLF			291	21		
VLF			[4]	5		
Combined EM/Mag.						
Time domain			1,020	348		
Frequency domain	5	6	167	52		
Frequency domain			[1]	200		
VLF	63	31	150	30		
VLF	[52]	30	[1]	3		
Induced polarization						
Time domain	136	105	220	206		
Frequency domain	93	111	95	157		
Frequency domain	[13]	166				
Magnetotelluric						
Natural field	[100]	30				
Controlled source	25	40				
Controlled source	[520]	100				
Remote sensing						
Total	7,582	839	99,025	4,888		
	[2,025]	582	[19]	252	[52]	15

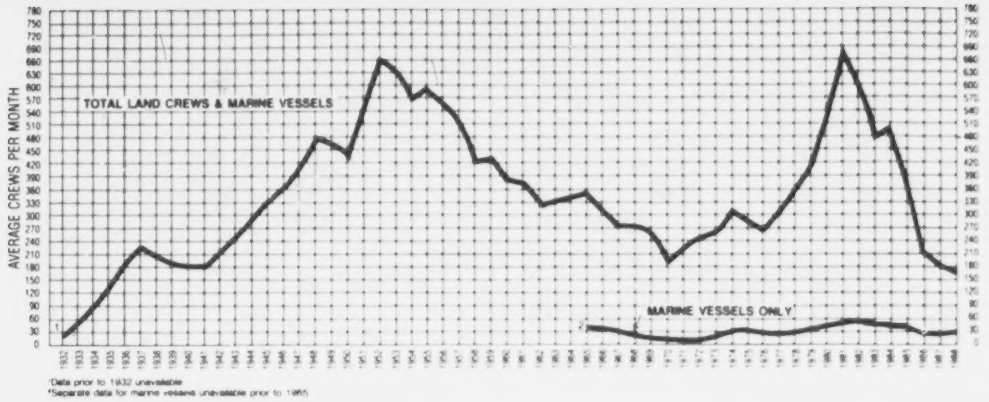
AVERAGE CREWS PER MONTH
TOTAL LAND CREWS & MARINE VESSELS
MARINE VESSELS ONLY[2]
[1]Data prior to 1932 unavailable
[2]Separate data for marine vessels unavailable prior to 1955

FIG. 5. History of seismic exploration activity in the U.S., 1932-88. (The total crews working in a given year is not synonymous with the crew-months worked that year.

Table 14B. Eastern hemisphere land mining activity in 1988 in US$ (thousands).

	Europe		Africa		Middle East		Far East		Australia/New Zealand	
Survey method	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost
Seismic (*P*-wave)										
Dynamite	99	2,130			37	350	65	1,600	40	50
Weight drop									80	10
Vibratory	33	99	994	4,080						
Seismic (refraction)										
Dynamite							[88]	10		
Gravity	703	319	8,015	364					135	11
Gravity	[7,770]	298	[2,000]	44			[5,162]	49	[3,100]	165
Magnetic	3,300	145	2,617	359			31	6	1,228	124
Magnetic			[2,000]	44			[60,453]	594	[1]	3
Resistivity			3	3						
Resistivity	[182]	105	[5,056]	170	[15]	8	[33,620]	350	[27]	18
Self-potential							[51,120]	700		
Electromagnetic										
Time domain	43	55	59	6					67	61
Time domain			[3,520]	240					[8]	247
Frequency domain	120	45	39	13			18	12		
Frequency domain			[1,000]	180					[2]	46
VLF	198	65	236	10					11	2
Combined EM/Mag.										
Frequency domain	1	260					9	2		
VLF							5	4		
Induced polarization										
Time domain	400	195	567	145			15	120		
Time domain							[43,020]	141	[12]	97
Frequency domain							3	5		
Magnetotelluric										
Controlled source							[1,000]	50		
Radiometric										
Gamma ray			291	12						
Other			9	14						
Other			[1,800]	3					[1]	2
Total	4,897	3,313	12,830	5,010	37	350	146	1,750	1,561	363
	[7,952]	403	[15,376]	682	[15]	8	[194,463]	1,895	[3,151]	580

Table 15. Worldwide groundwater and engineering activity in 1988.

Survey method	Area			Time *		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic (*P*-wave)						
Dynamite	57		750	4.6	4.0	166.6
Compressed air	506	1,415		9.7		1,166.7
Electrical	11,464			70.1		5,164.5
Gas exploder	233			.2		48.0
Implosive	962			6.3		1,512.0
Weight drop	60	173		2.2	.9	103.6
Solid chemical		10		1.0		12.5
Vibratory	53			1.8		159.0
Seismic (*S*-wave)						
Electrical	45			1.0		30.0
Weight drop			1,000	.5		20.0
Other	10			4.0		330.0
Seismic (refraction)						
Dynamite	196	2		19.6	7.5	524.3
Weight drop	25	118		7.7	3.9	97.7
Solid chemical	24			2.4		68.4
Other				.3		3.0
3-D seismic						
Line-miles	135			.2		60.0
Gravity	2,123	8,187		13.1	.6	627.7
Magnetic	20,634	438		9.9	.2	263.7
Resistivity	1,268	4,297	94,659	89.3	29.9	1,278.6
Self-potential	6	41	7,261	1.0		22.1
Sonic/velocity logging			12,756		10.0	96.6
Electromagnetic						
Time domain	80	146	2,291	2.0	7.8	63.3
Frequency domain	4,049	82		11.1	5.1	222.0
Induced polarization						
Time domain	15	11	1,000	1.4	.4	10.1
Frequency domain	50				2.0	6.6
Magnetotelluric						
Controlled source		100		1.0		40.0
Radiometric						
Gamma ray	3,833	50	36,344	4.3	4.3	109.4
Remote sensing						
Thermal infrared			7,200	1.0		20.0
Other	4,500			6.0		750.0
Temperature gradient		11	1,700	2.7		44.0
VSP		1		.1		1.0
Other	14,313	299	47,132	23.6	33.2	3,388.7
Total	64,645	15,381	212,093	298.4	110.1	16,410.5

Table 16. Worldwide geothermal activity in 1988.

Survey method	Area			Time *		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic (*P*-wave)						
Dynamite			600	.6		6.6
Passive monitoring		32		37.0		163.0
Gravity	395	820		10.0	3.0	109.0
Magnetic	16			.5		5.0
Resistivity	25	133		3.2		68.7
Electromagnetic						
Time domain		800		6.0		308.0
Magnetotelluric						
Natural field		812		30.0		2,349.4
Radiometric						
Gamma ray			120	.2		.4
Temperature gradient			19,400	1.0		20.0
Other	245	5		8.0		180.0
Total	681	2,602	20,190	96.5	3.0	3,210.1

*Includes government and university activity.

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method.

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew-month or man-month*	Average cost/mile or (foot) or [station]
Petroleum exploration						
Land						
Seismic (*P*-wave)						
Dynamite	1,885.8	94,445	343,304,572	50	182,046	3,635
Dynamite	6.5	[49]	1,400,000	[8]	215,385	[28,571]
Dynamite	6.0*	[588]	25,750	[98]*	4,292*	[44]
Compressed air	268.1	18,686	86,528,200	70	322,746	4,631
Compressed air	1.0	[31]	230,400	[31]	230,400	[7,432]
Gas exploder	7.0	350	6,700	50	957	19
Weight drop	61.9	4,564	18,220,233	74	294,349	3,992
Vibratory	1,560.5	100,655	266,645,134	64	170,863	2,649
Vibratory	7.7	[39]	1,705,000	[5]	220,000	[43,718]
Seismic (*S*-wave)						
Dynamite	1.0	50	200,000	50	200,000	4,000
Compressed air	2.0	54	305,000	27	152,500	5,648
Vibratory	5.0	200	967,000	40	193,400	4,835
Seismic (refraction)						
Dynamite	.4	196	4,000	490	10,000	20
Weight drop	.4	196	4,000	490	10,000	20
Vibratory	4.0	126	489,280	32	122,320	3,883
3-D seismic						
Line-miles	145.0	2,844	52,536,911	20	362,324	18,473
Square miles	70.1	1,060	34,431,075	15	491,171	32,458
Square miles	1.0	[6]	256,000	[6]	256,000	[42,667]
Gravity	102.9	13,658	2,459,750	133	23,893	180
Gravity	68.8	[21,779]	1,088,271	[316]	15,813	[50]
Gravity	12.0*	2,500	122,900	208*	10,242*	49
Gravity	.7*	[250]	45,000	[357]	64,286*	[180]
Electromagnetic						
Time domain	2.0	62	280,000	31	140,000	4,516
Time domain	4.5	[700]	250,000	[156]	55,556	[357]
Magnetotelluric						
Natural field	2.0	100	530,000	50	265,000	5,300
Natural field	31.0	[557]	1,949,000	[18]	62,871	[3,499]
Controlled source	6.5	155	225,000	24	34,615	1,452
VSPs	42.0	[154]	1,400,000	[4]	33,333	[9,091]
VSPs	1.0*	[3]	5,700	[3]*	5,700*	[1,900]
Other	3.0	1,875	56,250	625	18,750	30
Other	3.5	[133]	510,000	[38]	145,714	[3,835]
Transition zone						
Seismic (*P*-wave)						
Dynamite	15.5	205	2,970,000	13	191,613	14,488
Compressed air	100.5	25,116	3,720,400	250	37,019	148
3-D seismic						
Line-miles	7.0	870	800,000	124	114,286	920
Electromagnetic						
Time domain	1.0	46	180,000	47	180,000	3,863
Marine						
Seismic (*P*-wave)						
Dynamite	.5	48	96,000	96	192,000	2,000
Compressed air	673.8	491,585	225,467,891	730	334,606	459
3-D seismic						
Line-miles	99.9	124,795	44,834,600	1,249	448,660	359
Gravity	34.3	49,445	1,334,000	1,442	38,892	27
Magnetic	10.2	11,300	47,000	1,102	4,585	4
VSPs	.1	1	50,000	10	500,000	50,000
VSPs	8.0	[15]	300,000	[2]	37,500	[20,000]
VSPs	31.2	[94]	940,000	[3]	30,128	[10,000]
Airborne						
Gravity	15.0	26,250	1,494,900	1,750	99,660	57

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Petroleum exploration, Airborne, continued						
Magnetic	29.7	119,499	4,509,607	4,017	151,583	38
Combined EM/Mag						
Time domain	1.0	3,200	51,200	3,200	51,200	16
Frequency domain	22.4	56,000	4,900,000	2,500	218,750	88
Remote sensing						
Side-scan radar	2.7	180,000	1,300,000	66,667	481,481	7
Drill hole						
Sonic/velocity logging	6.0	[112]	1,680,000	[19]	280,000	[15,000]
Sonic/velocity logging	12.0	[306]	2,509,000	[26]	209,083	[8,199]
Resistivity	.1	(1,500)	5,000	(15,000)	50,000	(3)
Other	8.7*	[1,820]	500,500	[209]*	57,529*	[275]
Petroleum development						
Land						
Seismic (*P*-wave)						
Dynamite	14.6	609	6,942,000	42	475,479	11,399
Vibratory	3.9	227	1,415,000	58	362,821	6,233
3-D seismic						
Square miles	7.2	105	3,477,000	15	482,917	32,926
Gravity	49.5	20,683	3,104,000	418	62,707	150
Resistivity	15.5	[234]	135,625	[15]	8,750	[580]
Magnetotelluric						
Natural field	2.0	150	30,000	75	15,000	200
Controlled source	1.3	[72]	42,000	[55]	32,308	[583]
VSPs	2.0	[6]	30,000	[3]	15,000	[5,000]
Marine						
Seismic (*P*-wave)						
Compressed air	7.5	2,749	2,957,000	367	394,267	1,076
3-D seismic						
Line-miles	8.5	18,990	5,573,000	2,234	655,647	293
Drill hole						
Sonic/velocity logging	1.9	[4]	40,000	[2]	21,053	[10,000]
Other	1.0	[3,000]	63,000	[2,857]	60,000	[21]
Other	3.6	(23,400)	514,000	(6,500)	142,778	(22)
Other	11.1*	[2,330]	640,750	[210]*	57,725*	[275]
Minerals						
Land						
Seismic (*P*-wave)						
Dynamite	16.8	277	4,209,200	16	249,804	15,152
Weight drop	2.7	80	112,000	30	41,481	1,391
Solid chemical	.2	1	1,500	1	6,000	5,000
Vibratory	13.8	1,027	4,179,000	74	302,826	4,068
Seismic (refraction)						
Dynamite	2.1	50	91,245	24	43,244	1,807
Dynamite	.5	[88]	10,000	[176]	20,000	[114]
Dynamite	1.2*	1	4,600	1*	3,833*	3,833
Gravity	39.0	11,298	589,625	290	15,119	52
Gravity	44.3	[18,438]	637,020	[416]	14,380	[35]
Gravity	56.4*	928	282,200	16*	5,004*	304
Gravity	7.0*	[888]	18,500	[127]*	2,643*	[21]
Magnetic	135.2	102,841	4,385,020	761	32,431	43
Magnetic	19.6	[62,463]	669,931	[3,182]	34,128	[11]
Magnetic	42.1*	2,440	157,650	58*	3,738*	65
Resistivity	.6	8	8,500	13	14,167	1,063
Resistivity	35.4	[38,880]	723,792	[1,026]	20,412	[19]
Resistivity	.2*	[25]	8,000	[125]*	40,000*	[320]
Self-potential	.2	5	5,000	25	25,000	1,000
Self-potential	10.2	[51,120]	700,000	[5,012]	68,627	[14]
Electromagnetic						
Time domain	11.9	2,527	333,100	211	27,828	132
Time domain	13.4	[3,582]	522,532	[267]	38,966	[146]
Time domain	9.0*	148	86,500	16*	9,611*	583
Time domain	2.0*	[20]	60,000	[10]*	30,000*	[3,000]

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Minerals, Land, continued						
Frequency domain	10.2	97	45,300	10	4,441	463
Frequency domain	3.8	[1,005]	230,290	[264]	60,444	[229]
Frequency domain	12.5*	347	75,000	28*	6,000*	216
Frequency domain	1.0*	[20]	10,000	[20]*	10,000*	[500]
VLF	11.3	321	16,500	28	1,460	51
VLF	1.0	[4]	5,000	[4]	5,000	[1,250]
VLF	15.3*	415	82,000	27*	5,342*	198
Combined EM/Mag.						
Time domain	6.5	1,020	348,300	157	53,585	341
Frequency domain	7.0	181	61,300	26	8,757	338
Frequency domain	10.0	[1]	200,000	[1]	20,000	[200,000]
Frequency domain	52.0*	1	260,000	1*	5,000*	200,000
VLF	7.0	218	65,380	31	9,340	299
VLF	.5	[1]	3,000	[2]	6,000	[3,000]
VLF	3.0*	[52]	30,000	[17]*	10,000*	[577]
Induced polarization						
Time domain	42.9	919	571,000	21	13,295	621
Time domain	16.9	[43,032]	239,363	[2,543]	14,147	[6]
Time domain	40.2*	420	201,000	10*	4,994*	479
Frequency domain	14.0	176	213,500	13	15,250	1,208
Frequency domain	4.2	[13]	166,000	[3]	39,524	[12,769]
Frequency domain	.5*	15	60,000	30*	120,000*	4,000
Magnetotelluric						
Natural field	.5	[100]	30,000	[200]	60,000	[300]
Controlled source	1.0	25	40,000	25	40,000	1,600
Controlled source	4.4	[1,520]	150,000	[345]	34,091	[99]
Radiometric						
Gamma ray	9.5	291	12,000	31	1,263	41
Remote sensing						
Other	.1*	1	5,000	5*	50,000*	10,000
Other	1.0	9	14,500	9	14,500	1,611
Other	.7	[1,801]	5,750	[2,573]	8,214	[3]
Marine						
3D seismic						
Square miles	.5	180	150,000	360	300,000	833
VSP	.2	[2]	5,000	[10]	25,000	[2,500]
Other	5.2	40,000	4,500,000	7,619	857,143	113
Airborne						
Gravity	.3	[1]	9,000	[3]	30,000	[9,000]
Magnetic	50.7	302,378	6,618,446	5,961	130,464	22
Magnetic	.5*	500	20,000	1,000*	40,000*	40
Electromagnetic						
Time domain	3.0	2,628	86,560	756	28,853	38
Combined EM/Mag.						
Time domain	13.4	35,085	1,184,880	2,618	88,424	34
Frequency domain	10.0	2,600	250,000	260	25,000	96
VLF	27.7	45,134	1,945,582	1,629	70,238	43
Radiometric						
Gamma ray	3.0	18,050	180,500	6,017	60,167	10
Remote sensing						
Thermal infrared	5.0	24,860	200,000	4,972	40,000	8
Microwave radiometry	.2	870	20,000	3,480	80,000	23
Remote sensing						
Multispectral scanning	5.0	24,860	200,000	4,972	40,000	8
Other	6.0	41	2,843,000	7	473,833	69,173
Drillhole						
Magnetic	.2	(1,500)	2,500	(6,000)	10,000	(2)
Electromagnetic						
Time domain	1.7	[5]	47,312	[3]	27,507	[9,462]
Induced polarization						
Time domain	2.5	(10,000)	35,000	(4,000)	14,000	(4)
Time domain	1.0*	(37,729)	13,000	(37,729)*	13,000*	(1)

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Minerals, Drillhole, continued						
Radiometric						
Gamma ray	.3	(1,061)	3,370	(3,031)	9,629	(3)
Gamma ray	1.0*	(36,088)	13,500	(36,088)*	13,500*	(1)
Other	1.1*	[270]	74,250	[245]*	67,500*	[275]
Other	1.5*	(85,300)	38,000	(56,867)*	25,333*	(1)
Environmental						
Land						
Seismic (*P*-wave)						
Weight drop	1.0	1	32,500	2	30,952	18,056
Seismic (refraction)						
Dynamite	.5*	1	500	1*	1,000*	2,500
Weight drop	.8	7	17,500	9	21,875	2,397
Weight drop	.4*	1	2,700	2*	6,000*	3,000
Solid chemical	.2*	1	1,600	3*	8,000*	3,200
Gravity	.5*	[500]	2,500	[1,000]	5,000*	[5]
Magnetic	2.1	451	18,050	215	8,595	40
Magnetic	.2	[300]	2,000	[1,200]	8,000	[7]
Magnetic	1.5*	188	7,500	125*	5,000*	40
Magnetic	.2*	[1,363]	700	[6,815]	3,500*	[1]
Resistivity	.5	18	37,500	33	68,182	2,083
Resistivity	.5	[20]	15,000	[40]	30,000	[750]
Resistivity	3.1*	[73]	9,000	[23]	2,857*	[123]
Electromagnetic						
Time domain	.5*	63	2,500	126*	5,000*	40
Time domain	.6*	[92]	700	[153]	1,167*	[8]
Frequency domain	6.3	225	120,500	36	19,127	536
VLF	.1	[250]	5,000	[2,500]	50,000	[20]
Induced polarization						
Time domain	.2*	[2]	600	[8]*	2,400*	[300]
Other	1.7	37	43,000	21	24,571	1,162
Other	14.7	[305]	334,000	[21]	22,644	[1,095]
Environmental						
Airborne						
Radiometric						
Gamma ray	.1	167	4,626	2,783	77,100	28
Drill hole						
Resistivity	1.5	(22,000)	35,000	(14,667)	23,333	(2)
Radiometric						
Gamma ray	.7	(1,000)	8,000	(1,429)	11,429	(8)
Sonic/velocity logging	1.0*	[21]	2,000	[21]	2,000*	[95]
Other	.1*	[20]	5,500	[200]	55,000*	[275]
Engineering						
Land						
Seismic (*P*-wave)						
Dynamite	1.5	41	105,000	27	70,000	2,561
Compressed air	3.5	241	846,000	69	241,714	3,510
Compressed air	3.0	[1,415]	80,750	[472]	26,917	[57]
Electrical	7.9	1,229	1,912,000	156	242,025	1,556
Gas exploder	.2	233	48,000	1,165	240,000	206
Implosive	6.3	962	1,512,000	153	240,000	1,572
Weight drop	.7	25	30,000	33	40,000	1,200
Weight drop	.6*	[168]	2,100	[280]*	3,500*	[13]
Solid chemical	.5	[10]	12,000	[20]	24,000	[1,200]
Vibratory	1.8	53	159,000	29	88,333	3,000
Seismic (*S*-wave)						
Other	4.0	10	330,000	3	82,500	33,000
Seismic (refraction)						
Dynamite	5.3	24	144,540	5	27,017	5,876
Dynamite	4.5*	12	53,500	3*	11,889*	4,180
Dynamite	3.0*	[2]	13,500	[1]*	4,500*	[6,750]
Weight drop	7.5	22	38,800	3	5,173	1,764
Weight drop	.2	[118]	10,000	[590]	50,000	[85]

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Engineering, Land, continued						
Seismic refraction						
Weight drop	2.4*	1	41,000	1*	17,083*	24,118
Solid chemical	2.4	24	68,400	10	28,500	2,792
Other	.3	1	3,000	2	10,000	5,000
Gravity	9.7	2,023	493,600	207	50,626	244
Gravity	.9	[502]	21,818	[534]	23,211	[43]
Gravity	.4*	[80]	1,500	[200]	3,750*	[19]
Magnetic	1.0	375	15,000	375	15,000	40
Magnetic	.4	[120]	16,000	[267]	35,556	[133]
Magnetic	.1*	[280]	350	[2,800]	3,500*	[1]
Resistivity	1.2	26	5,900	21	4,720	716
Resistivity	4.5	[93]	66,625	[21]	14,806	[716]
Resistivity	4.1*	7	50,600	2*	12,193*	7,028
Resistivity	4.0*	[3]	10,000	[1]*	2,500*	[3,333]
Self-potential	.2	[1]	13,000	[4]	52,000	[13,000]
Electromagnetic						
Frequency domain	1.0	25	17,000	25	17,000	680
Frequency domain	1.1	[61]	36,127	[55]	32,843	[592]
Frequency domain	.1*	1	200	4*	4,000*	1,000
Frequency domain	4.0*	[4]	10,000	[1]*	2,500*	[2,500]
Induced polarization						
Time domain	.1*	1	600	1*	4,000*	3,000
Magnetotelluric						
Controlled source	1.0	[100]	40,000	[100]	40,000	[400]
VSPs	.1	[1]	1,000	[10]	10,000	[1,000]
Other	.5	10	20,000	20	40,000	2,000
Other	1.1	[60]	22,500	[55]	20,455	[375]
Other	1.0*	1	20,000	1*	20,000*	20,000
Marine						
Seismic (*P*-wave)						
Compressed air	3.2	265	240,000	83	75,000	906
Electrical	62.2	10,235	3,252,500	165	52,283	318
Seismic (*S*-wave)						
Electrical	1.0	45	30,000	45	30,000	667
3-D seismic						
Line-miles	.2	135	60,000	675	300,000	444
Magnetic	.2	20	7,000	80	28,000	350
Resistivity	.2	15	10,000	60	40,000	667
Remote sensing						
Other	6.0	4,500	750,000	750	125,000	167
Other	4.0	14,250	2,825,000	3,563	706,250	198
Drill hole						
Seismic (*S*-wave)						
Weight drop	.5	(1,000)	20,000	(2,000)	40,000	(20)
Sonic/velocity logging	10.0*	(10,400)	96,000	(1,040)*	9,600*	(9)
Induced polarization						
Time domain	.4	(1,000)	4,000	(2,500)	10,000	(4)
Temperature gradient	1.3	[3]	30,000	[2]	23,077	[10,000]
Temperature gradient	.3	(1,000)	3,000	(3,333)	10,000	(3)
Other	16.1	[49]	154,000	[3]	9,565	[3,143]
Other	.4*	[110]	30,250	[244]*	67,222*	[275]
Other	7.5*	(3,040)	116,000	(405)*	15,467*	(38)
Geothermal						
Land						
Seismic (*P*-wave)						
Dynamite	.1	1	1,600	2	16,000	8,000
Passive monitoring	37.0	[32]	163,000	[1]	4,405	[5,094]
Gravity	1.0	20	10,000	20	10,000	500
Gravity	9.0	[820]	84,000	[91]	9,333	[102]
Gravity	3.0*	375	15,000	125*	5,000*	40
Magnetic	.5	16	5,000	32	10,000	313
Resistivity	2.0	25	50,000	13	25,000	2,000
Resistivity	1.2	[133]	18,750	[111]	15,625	[141]

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Geothermal, Land, continued						
Electromagnetic						
Time domain	6.0	[800]	308,000	[133]	51,333	[385]
Magnetotelluric						
Natural field	30.0	[812]	2,349,400	[27]	78,313	[2,893]
Other	4.0	245	60,000	61	15,000	245
Other	4.0	[5]	120,000	[1]	30,000	[24,000]
Drill hole						
Seismic (*P*-wave)						
Dynamite	.5	(670)	5,000	(1,340)	10,000	(7)
Radiometric						
Gamma ray	.2	(120)	400	(480)	1,600	(3)
Temperature gradient	1.0	(19,400)	20,000	(19,400)	20,000	(1)
Groundwater						
Land						
Seismic (*P*-wave)						
Dynamite	2.5	6	50,600	3	20,240	8,032
Dynamite	4.0*	10	5,000	3*	1,250*	500
Weight drop	1.5	35	70,000	23	46,667	2,000
Weight drop	.3*	[5]	1,500	[17]*	5,000*	[300]
Solid chemical	.5	1	500	1	1,000	1,667
Seismic (refraction)						
Dynamite	14.3	159	312,850	11	21,878	1,965
Weight drop	1.5*	1	7,900	1*	5,097*	4,389
Gravity	1.0	100	30,000	100	30,000	300
Gravity	1.5	[7,585]	80,000	[5,057]	53,333	[11]
Gravity	.2*	[20]	850	[100]*	4,250*	[43]
Magnetic	4.2	355	25,000	85	5,952	70
Magnetic	.1*	[38]	350	[380]*	3,500*	[9]
Resistivity	44.0	1,205	432,820	27	9,837	359
Resistivity	34.3	[3,956]	433,625	[115]	12,642	[110]
Resistivity	4.0*	15	7,000	4*	1,750*	467
Resistivity	17.5*	[245]	204,750	[14]*	11,667*	[836]
Self-potential	.2	6	2,500	24	10,000	417
Self-potential	.5	[40]	5,000	[80]	10,000	[125]
Electromagnetic						
Time domain	.5	5	15,000	10	30,000	3,000
Time domain	1.5	[70]	25,000	[47]	16,667	[357]
Time domain	6.6*	75	21,500	11*	3,258*	284
Time domain	1.2*	[76]	1,300	[63]*	1,083*	[17]
Frequency domain	7.0	190	98,300	27	13,943	515
Frequency domain	.1*	1	400	2*	4,000*	2,000
Frequency domain	1.0*	[17]	10,000	[17]*	10,000*	[588]
Induced polarization						
Time domain	1.0	15	4,500	15	4,500	300
Time domain	.2*	[11]	1,000	[44]	4,000*	[91]
Frequency domain	2.0*	50	6,666	25*	3,333*	133
Radiometric						
Gamma ray	1.0	[50]	40,000	[50]	40,000	[800]
Temperature gradient	1.0	[8]	10,000	[8]	10,000	[1,250]
Other	.9	52	24,000	55	25,263	462
Airborne						
Magnetic	4.0	19,884	200,000	4,971	50,000	10
Electromagnetic						
Frequency domain	2.0	3,833	50,000	1,917	25,000	13
Radiometric						
Gamma ray	2.0	3,833	50,000	1,917	25,000	13
Drill hole						
Sonic/velocity logging	.1*	(2,356)	600	(117,800)*	30,000*	(1)

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Groundwater, Drillhole, continued						
Self-potential	.1*	(7,261)	1,600	(121,017)*	26,667*	(1)
Resistivity	5.0	(65,628)	50,500	(13,126)	10,100	(1)
Other	24.0*	(11,284)	80,000	(470)*	3,333*	(7)
Radiometric						
Gamma ray	1.3	(5,115)	3,860	(3,789)	2,859	(1)
Gamma ray	4.2*	(21,250)	13,333	(5,000)*	3,137*	(1)
Gamma ray	.1*	(9,979)	2,300	(124,738)*	28,750*	(1)
Remote sensing						
Thermal infrared	1.0	(7,200)	20,000	(7,200)	20,000	(3)
Temperature gradient	.1	(700)	1,000	(7,000)	10,000	(1)
Electromagnetic						
Time domain	.1*	(2,291)	500	(114,550)	25,000*	(1)
Other	1.0	(32,808)	75,000	(32,808)	75,000	(2)
Other	.3*	[80]	22,000	[267]*	73,333*	[275]
Resistivity	.2*	(29,031)	6,800	(120,963)*	28,333*	(1)
Oceanography						
Marine						
Seismic (*P*-wave)						
Electrical	.8	703	7,000	879	8,750	10
Electrical	3.0*	9,697	782,600	3,232*	260,867*	81
Seismic (*S*-wave)						
Compressed air	2.0	8,000	700,000	4,000	350,000	88
Seismic (refraction)						
Compressed air	3.0	6,500	1,200,000	2,167	400,000	185
Magnetic	.8	3,770	80,000	4,713	100,000	21
Remote sensing						
Side-scan radar	1.0	4,800	300,000	4,800	300,000	63
Drill hole						
Temperature gradient	7.0	(984)	600,000	(141)	85,714	(610)
Airborne						
Magnetic	4.0*	27,744	471,648	6,936*	117,912*	17
Research						
Land						
Seismic (*P*-wave)						
Dynamite	12.1	467	2,075,600	39	171,537	4,445
Compressed air	7.5	78	2,958,701	10	391,881	37,835
Compressed air	.5	[75]	3,000	[150]	6,000	[40]
Weight drop	1.5	5	135,000	3	90,000	27,000
Vibratory	13.2	756	3,786,000	57	286,818	5,008
Other	18.0	[750]	7,500	[42]	417	[10]
Seismic (*S*-wave)						
Compressed air	1.5	54	245,000	36	163,333	4,537
Weight drop	.5	1	35,000	2	70,000	35,000
Vibratory	12.0	12	20,000	1	1,667	1,667
Vibratory	3.0	[100]	70,000	[33]	23,333	[700]
Other	18.0	[750]	7,500	[42]	417	[10]
Seismic (refraction)						
Dynamite	5.0	330	200,000	66	40,000	606
Gravity	9.8	[7,300]	40,000	[740]	4,057	[5]
Gravity	7.0*	5,388	28,500	770*	4,071*	5
Gravity	34.2*	[6,208]	81,000	[182]*	2,368*	[13]
Magnetic	.1	[630]	25,000	[10,500]	416,667	[40]
Magnetic	2.0*	500	20,000	250*	10,000*	40
Resistivity	.6	4	3,230	8	5,383	673
Resistivity	.1	[161]	5,000	[2,683]	83,333	[31]
Self-potential	1.5	[6]	78,000	[4]	52,000	[13,000]
Electromagnetic						
Time domain	1.0	31	180,000	31	180,000	5,806
Time domain	4.0	[43]	150,000	[11]	37,500	[3,488]
Time domain	5.0*	[68]	200,000	[14]*	40,000*	[2,941]
VLF	.1	1	3,000	10	30,000	3,000

Table 17. Worldwide average unit costs in 1988 by survey objective, type, and method (cont).

Survey objective, type and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Research, Land, continued						
Combined EM/Mag.						
Frequency domain	8.0*	2,430	80,000	304*	10,000*	33
VLF	.5	300	15,000	600	30,000	50
VLF	3.0*	4,000	30,000	1,333*	10,000*	8
Magnetotelluric						
Natural field	1.0	[23]	4,000	[23]	4,000	[174]
Natural field	6.0*	230	60,000	38*	10,000*	261
Remote sensing						
Thermal infrared	.1*	145	10,000	1,450*	100,000*	69
Other	1.0*	50	50,000	50*	50,000*	1,000
Other	4.0	[132]	120,000	[33]	30,000	[909]
Transition zone						
Seismic (*P*-wave)						
Compressed air	.3	8	67,000	27	223,333	8,375
Marine						
Seismic (*P*-wave)						
Compressed air	7.3	13,995	1,774,633	1,917	243,100	127
Other	2.0	1,000	24,000	500	12,000	24
Gravity	12.4	63,568	3,685,269	5,126	297,199	58
Magnetic	7.6	52,648	4,218,961	6,927	555,126	80
Airborne						
Magnetic	19.8	95,300	503,000	4,813	25,404	5
Drill hole						
Resistivity	.1	(1,015)	1,000	(101,500)	100,000	(1)
Resistivity	.5*	(2,000)	1,000	(4,000)	2,000*	(1)
Self-potential	.1	(1,015)	1,000	(101,500)	100,000	(1)
Self-potential	.5*	(2,000)	1,000	(4,000)*	2,000*	(1)
Radiometric						
Gamma ray	2.0	(57,161)	20,370	(27,883)	9,937	(1)
Temperature gradient	.3	(10,000)	1,500	(33,333)	5,000	(1)
Other	.3	(10,000)	1,500	(33,333)	5,000	(1)
Other	4.0*	[5]	160,000	[1]*	40,000*	[32,000]

Land mining

Tables 14A and 14B report expenditures and methods utilized for land mining in the Western and Eastern Hemispheres.

Engineering, geothermal, groundwater, oceanography, and research

Table 15 reports engineering and groundwater activity. Table 16 contains worldwide geothermal work. Average unit costs for all survey objectives, types, and methods can be found in Table 17. Expenditures for groundwater and engineering activity increased 29 percent (Table 15) over 1987's levels. Geothermal activity is up from the previous year with an increase in expenditures of 185 percent. Oceanography expenditures increased by 135 percent and research increased by 104 percent when compared to 1987 numbers.

Summary

All survey objectives showed an increase in expenditures in 1988 when compared to 1987. Some of these increases may be a result of under-reporting in the 1987 report. A higher percentage of those surveyed returned their forms this year, but there continue to be companies that decline to return the survey questionnaires for reasons which vary from staff reductions to concern about confidentiality. It is also true that many firms which contributed data in past years are no longer in existence. The committee will continue to encourage more complete reporting and monitor new and changing trends in the industry.

Acknowledgments

This report was made possible through the contributions of statistical data by companies, contractors, governmental agencies, and universities. For many of these organizations, compilation of these data was a long and tedious task. The Geophysical Activity Committee expresses sincere appreciation to all those individuals who were instrumental in preparing and submitting their activity questionnaires. The committee welcomes comments and suggestions on ways to improve this report.

Karen Goodfellow, Assistant Chairman, was responsible for much of the work in obtaining and maintaining the accuracy of these data for the Geophysical Activity Report. A special note of thanks goes to Karen, Suzee Schulze, Jane Salas, Jerry Henry, and the rest of the SEG staff who worked on this project. I would also like to thank H. T. Konkler for the long hours he worked with the computer.

References

Geophysical Activity in 1987 LEADING EDGE, August 1988, 33-56.